

**CALIFORNIA
IMPLEMENTATION GUIDELINES FOR
ESTIMATING MASS EMISSIONS OF
FUGITIVE HYDROCARBON LEAKS
AT PETROLEUM FACILITIES**

February 1999

**CALIFORNIA
IMPLEMENTATION GUIDELINES FOR
ESTIMATING MASS EMISSIONS OF
FUGITIVE HYDROCARBON LEAKS
AT PETROLEUM FACILITIES**

Prepared by:

**The California Air Pollution Control Officers Association
Engineering Managers Committee
and
The California Air Resources Board Staff**

February 1999

ACKNOWLEDGMENTS

The following agencies participated in the development of these guidelines.

Bay Area Air Quality Management District
California Air Resources Board
San Joaquin Valley Unified Air Pollution Control District
San Luis Obispo Air Pollution Control District
Santa Barbara County Air Pollution Control District
South Coast Air Quality Management District
Ventura County Air Pollution Control District

AIR RESOURCES BOARD REVIEW

The staff of the California Air Resources Board has reviewed and approved the guidelines. Staff approval of the guidelines does not necessarily reflect approval of the guidelines by the Board.

TABLE OF CONTENTS

<u>CONTENTS</u>	<u>PAGE</u>
I. PURPOSE	1
II. BACKGROUND	1
III. DISCUSSION AND CAPCOA RECOMMENDATIONS	3
IV. METHODS OF CALCULATING FUGITIVE HYDROCARBON EMISSIONS FROM EQUIPMENT LEAKS	6
V. COMPONENT IDENTIFICATION AND COUNTING METHODOLOGY	21
VI. COMPONENT SCREENING PROCEDURES	26
VII. LEAK QUANTIFICATION METHODS	30
VIII. DEFINITIONS	32
REFERENCES	38
APPENDICES	
A. DOCUMENTATION OF GUIDELINES DEVELOPMENT	
B. FLOW CHARTS OF DATA SET USED IN DEVELOPMENT OF CORRELATION EQUATIONS AND EMISSION FACTORS	
C. DILUTION PROBE VERIFICATION	

CALIFORNIA IMPLEMENTATION GUIDELINES FOR ESTIMATING MASS EMISSIONS OF FUGITIVE HYDROCARBON LEAKS AT PETROLEUM FACILITIES

I. PURPOSE:

The purpose of the guidelines is to facilitate the estimation of fugitive emissions from equipment components in the petroleum industry in the State of California. These guidelines contain some recommendations that all districts in California will apply consistently and some recommendations that each district may elect to use at its discretion.

II. BACKGROUND:

Beginning in 1993, the results of several studies conducted to improve the methodologies used for estimating fugitive hydrocarbon mass emissions from equipment components in the petroleum industry were published. The Western States Petroleum Association (WSPA) and the American Petroleum Institute (API) jointly commissioned the 1993 refinery equipment leak report to evaluate fugitive emissions collected from five petroleum refineries (the 1993 Refineries Study). API also commissioned the 1993 marketing terminal equipment leak report which included screening of four marketing terminals and the collection of screening and bagging data from three of the four marketing terminals (the 1993 Marketing Terminals Study). API, along with the Gas Research Institute, jointly commissioned the 1993 and 1995 oil and gas production reports, which included bagging and screening data from 24 facilities (the 1993/1995 Oil and Gas Production Study). In addition to these studies, screening data from 17 marketing terminals were also collected and compiled by API. The bagging and screening data from these industry-conducted studies are considered by the United States Environmental Protection Agency (U.S. EPA) to represent a significant improvement over data previously collected and analyzed.

Using information from the above studies and reports, the U.S. EPA developed new default zero factors, correlation equations, and pegged factors for estimating fugitive hydrocarbon emissions from equipment components in the petroleum industry as a whole. Also, the U.S. EPA developed new average emission factors and screening value range factors for the marketing terminal segment of the industry and new average emission factors and screening value range factors for the oil and gas production segment of the industry. These new factors and correlation equations are contained in the U.S. EPA Protocol, dated November 1995, entitled *1995 Protocol for Equipment Leak Emission Estimates* (EPA-453/R-95-017, "the 1995 EPA Protocol").

The 1995 EPA Protocol also presents procedures for estimating mass emissions from equipment leaks and describes the methodologies to be used. The methodologies include the following: four different methods for estimating total organic emissions from equipment leaks; EPA Reference Test Method 21 as the requirement for the use of a portable monitoring instrument; and, methodologies for bagging components and collecting data to generate unit-specific correlation equations.

In reviewing the 1995 EPA Protocol, the California Air Pollution Control Officers Association (CAPCOA), identified several technical corrections and adjustments that improve the accuracy of the 1995 EPA Protocol's factors and correlation equations. CAPCOA believes these corrections and adjustments significantly affect estimates of fugitive hydrocarbon emissions from California facilities.

CAPCOA's concerns have been expressed to the U.S. EPA. Since October 1996 representatives of CAPCOA, individual California air pollution control districts (districts) and the California Air Resources Board (CARB) have engaged in constructive dialogue with the U.S. EPA and the petroleum industry to address concerns expressed by CAPCOA. Documentation of this effort is contained in Appendix A. In general, CAPCOA expressed the following concerns:

1. Blowthrough Bagging Method Leaks - The bagged data for refineries and marketing terminals used in the development of correlation equations and factors were obtained using the blowthrough bagging method which did not account for hydrocarbon leaking into the bags.
2. Facility Grouping - Grouping data from all three facility types (refineries, marketing terminals, oil and gas production) to develop one set of pegged factors for the entire petroleum industry can significantly underestimates oil and gas production emissions.
3. Average Emission Factors - Average emission factors should represent the emissions from both controlled and uncontrolled facilities.
4. Component Identification and Counting - Existing component counts used by California districts may be inconsistent with the component count methodology used in the underlying studies.
5. ROC/THC Ratios - ROC/THC ratios of pegged factors produced by combining data from all segments of the petroleum industry may differ significantly from ROC/THC ratios currently being used by California districts.

6. Dilution Probes - The undemonstrated reliability of organic vapor analyzers (OVAs) equipped with dilution probes, in distinguishing one concentration range from another, casts uncertainty on pegged emission factors and correlation equations above 10,000 ppmv. OVAs were used to monitor fugitive hydrocarbon emissions during the underlying studies.

III. DISCUSSION AND CAPCOA RECOMMENDATIONS

Presented below are specific points of discussion and CAPCOA recommendations. Over the course of developing the guidelines, CAPCOA and industry have agreed that some issues can be addressed while other issues will need further evaluation. In addition to the discussion here, Appendix A contains a summary of agreements, key outstanding issues and proposed resolutions.

Blowthrough Bagging Method Leaks

CAPCOA has provided its analysis which demonstrated that adjustment to the correlation equations and pegged source factors are merited. This analysis was documented in the Santa Barbara County Air Pollution Control District report, dated May 1, 1997, entitled *Review of the 1995 EPA Protocol: The Correlation Equation Approach to Quantifying Fugitive Hydrocarbon Emissions at Petroleum Industry Facilities* (the SBCAPCD report). A revised copy of this report is contained in Appendix A.

As stated in the SBCAPCD report, a review of the bagging data sets from refineries and marketing terminals identified the need for several apparent technical corrections and adjustments. These include the following: adjustments to account for hydrocarbon leaks in bags collected with the blowthrough method; removal of one set of data from components that were double counted; removal of data from components that exceeded the 1995 EPA Protocol's 5% O₂ concentrations criterion; inclusion of data that had been inadvertently omitted; and, inclusion of data from liquid leaks in additional pegged source calculations. The corrections and adjustments resulted in changes to default zero factors, correlation equations, and pegged factors, ranging on the order of a few percent to about 50 percent. At this time, CAPCOA recommends that the default zero factors, correlation equations, and pegged factors be corrected to account for the documented technical corrections and adjustments.

Facility Grouping

CAPCOA maintains that upstream and downstream operations differ in the following ways: process streams (e.g., production heavy liquid such as crude oil versus refinery heavy liquid such as diesel and kerosene); in process operations; and, in maintenance and/or maintenance frequency. These differences can produce differences in leak rates and leak frequencies among the various industry segments. At this time, this is an outstanding issue that is further discussed in Appendix A.

Average Emission Factors

The marketing terminal average emission factors were developed from screening data collected from facilities nationwide with varying degrees of inspection and maintenance (I&M) programs in place. Some of these facilities had agency mandated I&M programs while many may have had in-house preventive maintenance programs such as daily inspections and routine maintenance and services of major equipment. CAPCOA finds that the marketing terminal average emission factors represent averages of emissions from these facilities and that no control credit or deficit should be added to the factors.

The production of new refinery average emission factors was not one of the stated goals of the 1993 Refineries Study; therefore, no additional screening data were collected from refineries. This precluded the calculation of new average emission factors and screening value range factors for refineries. Refinery factors presented in the 1995 EPA Protocol are based on 1980 and 1982 refining fugitive emissions studies. In general, California refineries with existing I&M programs that routinely collect individual screening values are required to use either the Screening Value Range Method or the Correlation Equation Method (general or unit specific) instead of the Average Emission Factor Method.

At this time, the oil and gas production average emission factors are not included in the guidelines. This is an outstanding issue that is further discussed in Appendix A.

Component Identification and Counting

Components monitored in the development of the correlation equations and emission factors presented in the 1995 EPA Protocol were defined and counted using a specific methodology. That methodology may differ significantly from the procedures currently being used by some California districts. CAPCOA recommends that the component identification and counting methodology used in the underlying studies be used as the standard methodology throughout California. Section V of the guidelines provides the recommended component identification and counting methodology.

ROC/THC Ratios

Each of the three data sets (refineries, marketing terminals, oil and gas production) had unique ROC/THC ratios. Therefore, defining one general ROC/THC ratio based on combining

these data sets is not appropriate. For quantifying ROC emissions from THC data, district standard ratios or facility-specific ratios shall be used.

Dilution Probes

Compelling evidence indicates that screening data taken by OVAs fitted with dilutor kits are of undemonstrated reliability. Industry acknowledges that under certain conditions when using a dilution probe, resultant screening values can be in error. In addition, laboratory experiments conducted by CARB in September 1997 have shown that the dilution probe did not perform consistently (see CARB evaluation test report in Appendix C). However, the effect of using dilution probe measurements in the derivation of EPA's correlation equations and pegged emission factors has not been determined. At this time, this is an outstanding issue that is further discussed in Appendix A.

IV. METHODS OF CALCULATING FUGITIVE HYDROCARBON EMISSIONS FROM EQUIPMENT LEAKS:

The United States Environmental Protection Agency (U.S. EPA) Protocol, dated November 1995, entitled *1995 Protocol for Equipment Leak Emission Estimates* (EPA-453/R-95-017, “the 1995 EPA Protocol”) presents four different methods for estimating equipment leak emissions. The methods, in order of increasing refinement, are:

- Method 1: Average Emission Factor Method;
- Method 2: Screening Value Range Method;
- Method 3: Correlation Equation Method; and
- Method 4: The Unit-Specific Correlation Equation Method.

In general, a more refined method requires more data and provides more reliable fugitive hydrocarbon emission estimates. In the Average Emission Factor Method and the Screening Value Range Method, emission factors are combined with equipment counts to estimate emissions. To estimate emissions with the Correlation Equation Method, OVA-measured concentrations (screening values) for all equipment components are individually entered into correlation equations or counted as either default zeros or pegged components. In the Unit-Specific Correlation Equation Method, screening and actual mass emissions are measured as discussed in Section VII of the guidelines for a select set of individual equipment components at a site and then used to develop unit-specific correlation equations and pegged source factors. Screening values for all components are then entered into these unit-specific correlation equations and pegged source factors to estimate emissions.

Using CAPCOA recommendations, the U.S. EPA's four different methods can be applied and used to estimate fugitive emissions. Detailed discussion of the methods is presented in the 1995 EPA Protocol. Another source is the American Petroleum Institute (API) document, dated July 1997, entitled *Calculation Workbook for Oil and Gas Production Equipment Fugitive Emissions*, which provides step-by-step example calculations using each of the estimation methods outlined in the 1995 EPA Protocol. However, as discussed in Section III of the guidelines, some of the factors and correlation equations associated with the first three methods have been corrected and revised. Method 4 is not affected because it calls for the collection of site-specific data which are then used to develop unit-specific correlation equations and factors. Component counting, component screening, and the leak quantification must use the methods specified in Sections V, VI, and VII of the guidelines for the unit-specific equations and factors to be acceptable to the local districts.

Flow charts detailing the development of the 1995 EPA Protocol correlation equations and factors, the revisions made by CAPCOA, and the development of the oil and gas production correlation equations and factors are presented in Appendix B.

Presented below are CAPCOA's revised emission factors and correlation equations for calculating fugitive hydrocarbon emissions from the petroleum industry equipment components

using the estimation methods outlined in the 1995 EPA Protocol. Also discussed is the potential application of the methods by California districts.

Method 1: Average Emission Factor Method

The average emission factors represent average facility emissions and no control credit or deficit will be assumed. The Average Emission Factor Method may be used by refineries and marketing terminals to estimate overall emissions only when reliable site-specific screening data are not available. In the case of new projects, once an I&M program is in place and reliable site-specific screening data are available, the source may use either the Screening Value Range Method (Method 2), the Correlation Equation Method (Method 3), or the Unit Specific Correlation Equation Method (Method 4) to estimate emissions and make the appropriate adjustment to the original estimates. A new facility may also use existing I&M data from similar processes to estimate emissions provided that the data are accepted by the local districts as being representative of the new source.

Table IV-1a contains the 1995 EPA Protocol average emission factors for refineries and Table IV-1b contains the 1995 EPA Protocol average emission factors for marketing terminals. [NOTE: The 1995 EPA Protocol factors presented in Table IV-1b have not been revised to reflect the technical corrections and adjustments discussed in Section III of the implementation guidelines.]

The successful use of Method 1 (Average Emission Factor) requires the completion of the following five steps:

- Step 1. Components are separated into component types (i.e., non-flange connectors, flanges, open-ended lines, pump seals, valves, others).
- Step 2. Each component type is further separated into service types (gas, light liquid, or heavy liquid) if there are different emission factors for the service types.
- Step 3. The total number of components in each group (component type/service type) is determined.
- Step 4. The number of components in each group is multiplied by the corresponding average emission factor to obtain the sub-total of emissions from the group.
- Step 5. The sub-totals of emissions from all groups are added to give total emissions from the facility.

Thus,

$$\text{Emissions}_{\text{comp A, service X}} = (\text{Component}_{\text{comp A, service X}} \text{ Count \#}) \times (\text{Average Emission Factor}_{\text{comp A, service X}})$$

Total emissions = Summation of emissions from all component/service types

EXAMPLE - AVERAGE EMISSION FACTOR METHOD

Five thousand (5,000) components at a marketing terminal were counted and placed in the eight groups of component type/service type that correspond to the 1995 EPA Protocol average emission factors for marketing terminals. The number in each group was multiplied by the appropriate average emission factor in Table IV-1b, and the total emissions estimate for the marketing terminal was found to be 0.0944 kg/hr.

TABLE ex-1: CALCULATION USING THE AVERAGE EMISSION FACTOR METHOD TO ESTIMATE EMISSIONS AT A MARKETING TERMINAL

Component Type	Service Type	Number of Components installed at the Marketing Terminal	1995 Protocol Average Emission Factor (kg/hr/source)	Subtotals (kg/hr)
Valves	Gas	28	1.3E-05	0.0004
	Light Liquid	593	4.3E-05	0.0255
Pump seals	Gas	0	6.5E-05	0.0000
	Light Liquid	25	5.4E-04	0.0135
Others	Gas	20	1.2E-04	0.0024
	Light Liquid	85	1.3E-04	0.0111
Fittings	Gas	224	4.2E-05	0.0094
	Light Liquid	4,025	8.0E-06	0.0322
TOTAL	(kg/hr)	5,000		0.0944

TABLE IV-1a: 1995 EPA PROTOCOL REFINERY AVERAGE EMISSION FACTORS^a

Component Type	Service Type	Emission Factor (kg/hr/source) ^b
Valves	Gas	2.68E-02
	Light liquid	1.09E-02
	Heavy liquid	2.30E-04
Pump seals ^c	Light liquid	1.14E-01
	Heavy liquid	2.10E-02
Compressor seals	Gas	6.36E-01
Pressure relief valves	Gas	1.60E-01
Connectors	All	2.50E-04
Open-ended lines	All	2.30E-03
Sampling connections	All	1.50E-02

^aSource: *1995 EPA Protocol for Equipment Leak Emission Estimates* (EPA-453/R-95-017, November 1995) which referenced the 1980 Petroleum Refining Study (EPA-600/2-80-075c, April 1980). These factors are based on the 1980 Petroleum Refining Study.

^bThese factors are for non-methane organic compound emission rates.

^cThe light liquid pump seals factor can be used to estimate the leak rate from agitator seals.

TABLE IV-1b: 1995 EPA PROTOCOL MARKETING TERMINAL
AVERAGE EMISSION FACTORS^a

Component Type	Service Type	THC Emission Factor (kg/hr/source) ^b
Valves	Gas	1.3E-05
	Light liquid	4.3E-05
Pump seals	Gas	6.5E-05
	Light liquid	5.4E-04
Others (compressors and others) ^c	Gas	1.2E-04
	Light liquid	1.3E-04
Fittings (connectors and flanges) ^d	Gas	4.2E-05
	Light liquid	8.0E-06

^aSource: *1995 EPA Protocol Equipment Leak Emission Estimates* (EPA-453/R-95-017, November 1995). NOTE: These factors have not been corrected to reflect the technical corrections and adjustments discussed in Section III of the implementation guidelines.

^bThese factors are for total organic compound emission rates (including non-VOC's such as methane and ethane).

^cThe "Others" component type should be applied for any component type other than fittings, pumps, or valves.

^d"Fittings" were not identified as flanges or non-flanged connectors; therefore, the fitting emissions were estimated by averaging the estimates from the connector and the flange correlation equations.

Method 2: Screening Value Range Method

The Screening Value Range Method was formerly known as the Leak/No Leak Method. This method uses the screening data (instrument screening values, “SV”) to calculate the mass emission rates based on the component leak level (below 10,000 ppm = no leak, or 10,000 ppm or greater = leak). Some districts define leaks at lower levels than 10,000 ppmv. A district may choose to apply the 10,000 ppmv emission factors to all components above their leak definition. Such a policy will generally result in a conservative estimation of emissions. Facilities that record individual screening values for each component may prefer to use the Correlation Equation Method (Method 3) or the Unit Specific Correlation Equation Method (Method 4).

Table IV-2a contains the 1995 EPA Protocol screening value range factors for refineries; Table IV-2b contains the 1995 EPA Protocol screening value range factors for marketing terminals; and, Table IV-2c contains the CAPCOA-revised screening value range factors for oil and gas production separated by stream types. [NOTE: The 1995 EPA Protocol factors presented in Table IV-2b have not been revised to reflect the technical corrections and adjustments discussed in Section III of the implementation guidelines.]

The successful use of Method 2 (Screening Value Range) requires the completion of the following five steps:

Step 1. Components are separated into component types (i.e., non-flange connectors, flanges, open-ended lines, pump seals, valves, others).

Step 2. Each component type is further separated into service types (gas, light liquid, or heavy liquid) if there are different emission factors for the service types.

Step 3. The total number of components in each group (component type/service type) with screening values below 10,000 ppmv is determined. The total number of components in each group with screening values of 10,000 ppmv or more is determined.

Step 4. The number of components in each sub-group (component type/service type/screening value range) is multiplied by the corresponding screening value range factor to obtain the sub-total of emissions from the sub-group.

Step 5. The sub-totals of emissions from all sub-groups are added to give total emissions from the facility.

Thus,

$$\text{Emissions}_{\text{comp A, service X}} = (\text{Component}_{\text{comp A, service X}} \text{ Count } \#)_{\text{sv} < 10,000 \text{ ppmv}} \times (<10,000 \text{ ppmv Factor}_{\text{comp A, service X}}) + (\text{Component}_{\text{comp A, service X}} \text{ Count } \#)_{\text{sv} \geq 10,000 \text{ ppmv}} \times (\geq 10,000 \text{ ppmv Factor}_{\text{comp A, service X}})$$

Total emissions = Summation of emissions from all component/service types for both non-leakers and leakers

EXAMPLE - SCREENING VALUE RANGE METHOD

All components on three large heaters at a refinery were screened in accordance to Section VI of the implementation guidelines. The components were grouped by type, service (in this case all gas service), and screening value range. The number of components in each group was multiplied by the appropriate factor from Table IV-2a and the total emissions estimate for the heaters were found to be 2.56 kg/hr.

TABLE ex-2: CALCULATION USING THE SCREENING VALUE RANGE METHOD TO ESTIMATE EMISSIONS FROM THREE REFINERY HEATERS

Component Type/ (Service Type)	Screening Value Range (ppmv)	Number of Components Screened	1995 Protocol screening Value Range Factors (kg/hr/source)	Subtotals (kg/hr)
Valves (gas)	<10,000	164	6.0E-04	0.098
	≥10,000	7	2.626E-01	1.838
Pressure relief valves (gas)	<10,000	3	4.47E-02	0.134
	≥10,000	0	1.691	0.000
Connectors (gas)	<10,000	703	6.0E-05	0.042
	≥10,000	11	3.75E-02	0.413
Open-ended lines (gas)	<10,000	10	1.5E-03	0.015
	≥10,000	2	1.195E-02	0.024
TOTAL (kg/hr)		900		2.56

TABLE IV-2a: 1995 EPA PROTOCOL REFINERY SCREENING VALUE RANGE EMISSION FACTORS^a

Component Type	Service Type	< 10,000 ppmv Emission Factor (kg/hr/source) ^b	≥ 10,000 ppmv Emission Factor (kg/hr/source) ^b
Valves	Gas	6.0E-04	2.626E-01

	Light liquid	1.7E-03	8.52E-02
	Heavy liquid	2.3E-04	2.3E-04
Pump seals ^c	Light liquid	1.20E-02	4.37E-01
	Heavy liquid	1.35E-02	3.885E-01
Compressor seals	Gas	8.94E-02	1.608
Pressure relief valves	Gas	4.47E-02	1.691
Connectors	All	6.0E-05	3.75E-02
Open-ended lines	All	1.5E-03	1.195E-02

^aSource: 1995 EPA Protocol for Equipment Leak Emission Estimates (EPA-453/R-95-017, November 1995) which referenced the 1982 Petroleum Refining Study (EPA-450/3-82-010, 1982). These factors are based on the 1980 and 1982 refining fugitive emissions studies.

^bThese factors are for non-methane organic compound emission rates.

^cThe light liquid pump seals factor can be used to estimate the leak rate from agitator seals.

TABLE IV-2b: 1995 EPA PROTOCOL MARKETING TERMINAL
SCREENING VALUE RANGE EMISSION FACTORS^a

Component Type	Service Type	< 10,000 ppmv THC Emission Factor (kg/hr/source) ^b	≥ 10,000 ppmv THC Emission Factor (kg/hr/source) ^b
Valves	Gas	1.3E-05	NA
	Light liquid	1.5E-05	2.3E-02

Pump seals	Light liquid	2.4E-04	7.7E-02
Others (compressors and others) ^c	Gas	1.2E-04	NA
	Light liquid	2.4E-05	3.4E-02
Fittings (connectors and flanges) ^d	Gas	5.9E-06	3.4E-02
	Light liquid	7.2E-06	6.5E-03

^aSource: *1995 EPA Protocol for Equipment Leak Emission Estimates* (EPA-453/R-95-017, November 1995). NOTE: These factors have not been corrected to reflect the technical corrections and adjustments discussed in Section III of the implementation guidelines.

^bThese factors are for total organic compound emission rates (including non-VOC's such as methane and ethane). "NA" indicates that not enough data were available to develop the indicated emission factor.

^cThe "Others" component type should be applied for any component type other than fittings, pump seals, or valves.

^d"Fittings" were not identified as flanges or non-flanged connectors; therefore, the fitting emissions were estimated by averaging the estimates from the connector and the flange correlation equations.

TABLE IV-2c: CAPCOA OIL AND GAS PRODUCTION
SCREENING VALUE RANGE EMISSION FACTORS^a

Component Type	Service Type	< 10,000 ppmv THC Emission Factor (kg/hr/source) ^b	≥ 10,000 ppmv THC Emission Factor (kg/hr/source) ^b
Valves	Gas/Light Liquid	3.5E-05	1.386E-01
	Light Crude Oil	1.90E-05	7.07E-02
	Heavy Crude Oil	1.40E-05	N/A
Pump seals	Gas/Light Liquid	9.96E-04	8.9E-02
	Light Crude Oil	2.65E-04	8.9E-02
	Heavy Crude Oil	N/A	N/A
Others ^c	Gas/Light Liquid	1.47E-04	1.376E-01
	Light Crude Oil	1.31E-04	7.1E-03
	Heavy Crude Oil	5.7E-05	N/A
Connectors	Gas/Light Liquid	1.20E-05	2.59E-02
	Light Crude Oil	1.0E-05	2.34E-02
	Heavy Crude Oil	8.0E-06	N/A
Flanges	Gas/Light Liquid	2.80E-05	6.1E-02
	Light Crude Oil	2.4E-05	2.6E-01
	Heavy Crude Oil	2.3E-05	N/A
Open-ended lines	Gas/Light Liquid	2.4E-05	5.49E-02
	Light Crude Oil	1.8E-05	2.22E-02
	Heavy Crude Oil	1.5E-05	7.11E-02

^aSource: Fax Transmittal from STAR Environmental, dated December 17, 1997, entitled *Comparison of Screening Value Range Factors for Oil and Gas Production Operations*. These factors were developed using the separated oil and gas production default zero factors and pegged factors. Correlation equations for the petroleum industry (revised to reflect the technical corrections and adjustments discussed in Section III of the implementation guidelines) were used for components with screening values between background and 9,999 ppmv.

^bThese factors are for total organic compound emission rates (including non-VOC's such as methane and ethane) and apply to light crude, heavy crude, gas plant, gas production, and off shore facilities.

^cThe "Others" component type was derived from compressors, diaphragms, drains, dump arms, hatches, instruments, meters, pressure relief valves, polished rods stuffing boxes, relief valves, and vents. This "Others" component type should be applied for any component type other than connectors, flanges, open-ended lines, pumps, or valves.

Method 3: Correlation Equation Method

CAPCOA-revised 1995 EPA default zero factors, correlation equations, and pegged source factors for refineries and marketing terminals are presented in Table IV-3a.

As discussed in Section III (Blowthrough Bagging Method Leaks), technical corrections and adjustments were made to the data used in the 1995 EPA Protocol and revised correlation equations and emission factors were computed. The following guidelines are recommended for use with Table IV-3a: CAPCOA-revised 1995 EPA Correlation Equations and Factors for Refineries and Marketing Terminals.

- ▶ Default zero factors apply only when the screening value, corrected for background, equals 0.0 ppmv (i.e., the screening value is indistinguishable from the background reading).
- ▶ The correlation equations apply for actual screening values, corrected for background, between background and 9,999 ppmv and can be used for screening values up to 99,999 ppmv at the discretion of the local district.
- ▶ The 10,000 ppmv pegged factors apply for screening values, corrected for background, equal to or greater than 10,000 ppmv and are used when the correlation equations are used for screening values between background and 9,999 ppmv. The 100,000 ppmv pegged factors apply for screening values reported pegged at 100,000 ppmv and are used when the local district authorizes use of the correlation equations for screening values between background and 99,999 ppmv.
- ▶ Where multiple instrument screening values apply as with quarterly inspections, the average of the calculated mass emission estimates during the reporting period shall be used.

The successful use of Method 3 (Correlation Equation Method) requires the completion of the following six steps:

Step 1. Record each individual component screening value.

Step 2. Group the data by component type into three categories of screening ranges: default zeros range, correlation equations range, pegged source range.

Step 3. Multiply the number of components with instrument screening values in the default zeros range by the appropriate default zero factors.

Step 4. Enter each individual component screening value that is within in the correlation equations range into its appropriate correlation equation.

Step 5. Multiply the number of components with instrument screening values in the pegged range by the appropriate pegged factors.

Step 6. Add all calculated emissions to obtain the estimate of total emissions from the site.

Thus,

$$\text{Emissions}_{\text{comp A}} = \text{DZ}_A + \text{CE}_A + \text{PF}_A$$

$$\text{Total emissions} = \text{Summation of emissions from all component types}$$

Where,

$$\text{DZ}_A = (\text{Component}_A \text{ Count \#})_{\text{SV in default zero range}} \times (\text{Default Zero Factor}_A)$$

$$\text{CE}_A = \text{Summation of } (\text{Correlation Equation}_A)_{\text{for each comp A SV in corr. eqns. range}}$$

$$\text{PF}_A = (\text{Component}_A \text{ Count \#})_{\text{SV in pegged range}} \times (\text{Pegged Factor}_A)$$

EXAMPLE - CORRELATION EQUATION METHOD

Two hundred-sixty (260) components at a marketing terminal were screened in accordance to section VI of the implementation guidelines. The components were grouped by type and screening value (default zero, measurable screening value, pegged source). The number of default zeros and pegged sources of each type were multiplied by the appropriate factors from Table IV-3a. Correlation equations in Table IV-3a were used to calculate emissions from each component with a screening value that was above background but below 10,000 ppmv. Total emissions from the marketing terminal were calculated to be 0.2311 kg/hr.

TABLE ex-3: CALCULATION USING THE CORRELATION EQUATION METHOD TO ESTIMATE EMISSIONS FROM A MARKETING TERMINAL

Emissions From Default Zero Components

Component Type	Number of Default Zeros	CAPCOA Refineries and Marketing Terminals Factor (kg/hr)	Emissions (kg/hr)
Valve	46	7.8E-06	0.0004
Pump Seals	1	1.9E-05	0.0000
Others	7	4.0E-06	0.0000
Connectors	152	7.5E-06	0.0011
Flanges	38	3.1E-07	0.0000
Open Ends	2	2.0E-06	0.0000
Subtotal (kg/hr)			0.0015

Emissions From Pegged Source Components^a

Component Type	Number of Pegged Sources	CAPCOA Refineries and Marketing Terminals Factor (kg/hr)	Emissions (kg/hr)
Valve	1	0.064	0.0640
Pump Seals	0	0.089	0.0000
Others	0	0.082	0.0000
Connectors	2	0.030	0.0600
Flanges	1	0.095	0.0950
Open Ends	0	0.033	0.0000
Subtotal (kg/hr)			0.2190

^a pegged at 10,000 ppmv, less than 100,000 ppmv

EXAMPLE CONTINUED

Emissions From Components with Screening Values above Background but below 10,000 ppmv

Component Type	Screening Value (ppmv)	Correlation Equation (kg/hr)	Emissions (kg/hr)
Valve	300	$2.27E-06(SV)^{0.747}$	0.0002

Valve	5000	$2.27\text{E-}06(\text{SV})^{0.747}$	0.0013
Valve	7000	$2.27\text{E-}06(\text{SV})^{0.747}$	0.0017
Pump Seal	1200	$5.07\text{E-}05(\text{SV})^{0.622}$	0.0042
Other	2000	$8.69\text{E-}06(\text{SV})^{0.642}$	0.0011
Connector	75	$1.53\text{E-}06(\text{SV})^{0.736}$	0.0000
Connector	800	$1.53\text{E-}06(\text{SV})^{0.736}$	0.0002
Connector	3500	$1.53\text{E-}06(\text{SV})^{0.736}$	0.0006
Connector	9000	$1.53\text{E-}06(\text{SV})^{0.736}$	0.0012
Flange	50	$4.53\text{E-}06(\text{SV})^{0.706}$	0.0001

Subtotal (kg/hr) 0.0106

TOTAL EMISSIONS FROM ALL COMPONENTS

Default Zero	Subtotal (kg/hr)	0.0015
Pegged Source	Subtotal (kg/hr)	0.2190
Correlation Equation	Subtotal (kg/hr)	0.0106
TOTAL (kg/hr)		0.2311

TABLE IV-3a: CAPCOA-REVISED 1995 EPA CORRELATION EQUATIONS AND FACTORS FOR REFINERIES AND MARKETING TERMINALS ^a

Component Type/ Service Type	Default Zero Factor (kg/hr) ^b	Correlation Equation (kg/hr) ^c	Pegged Factor (kg/hr) ^d	
			10,000 ppmv	100,000 ppmv
Valves/All	7.8E-06	$2.27E-06(SV)^{0.747}$	0.064	0.138
Pump seals/All	1.9E-05	$5.07E-05(SV)^{0.622}$	0.089	0.610 ^e
Others ^f /All	4.0E-06	$8.69E-06(SV)^{0.642}$	0.082	0.138
Connectors/All	7.5E-06	$1.53E-06(SV)^{0.736}$	0.030	0.034
Flanges/All	3.1E-07	$4.53E-06(SV)^{0.706}$	0.095	0.095
Open-ended lines/All	2.0E-06	$1.90E-06(SV)^{0.724}$	0.033	0.082

^aSource: SBCAPCD Report, dated May 1, 1997, entitled *Review of the 1995 Protocol: The Correlation Equation Approach To Quantifying Fugitive Hydrocarbon Emissions At Petroleum Industry Facilities*. Technical corrections and adjustments were made to the refineries and marketing terminals bagged data, obtained by use of the blowthrough method, to account for the hydrocarbon leak flow rate.

^bThe default zero factors apply only when the screening value (SV), corrected for background, equals 0.0 ppmv (i.e., the screening value is indistinguishable from background reading). The default zero factors were based on the combined 1993 refinery and marketing terminal data only; default zero data were not collected from oil and gas production facilities.

^cThe correlation equations apply for actual screening values, corrected for background, between background and 9,999 ppmv and can be used for screening values up to 99,999 ppmv at the discretion of the local district.

^dThe 10,000 ppmv pegged factors apply for screening values, corrected for background, equal to or greater than 10,000 ppmv and are used when the correlation equations are used for screening values between background and 9,999 ppmv. The 100,000 ppmv pegged factors apply for screening values reported pegged at 100,000 ppmv and are used when the local district authorizes use of the correlation equations for screening values between background and 99,999 ppmv.

^eOnly 3 data points were available for the pump seals 100,000 ppmv pegged factor.

^fThe “other” component type includes instruments, loading arms, pressure relief valves, vents, compressors, dump lever arms, diaphragms, drains, hatches, meters, and polished rods stuffing boxes. This “others” component type should be applied for any component type other than connectors, flanges, open-ended lines, pumps, or valves. However, if an acceptable emission estimate exists which more accurately predicts emissions from the source, then that emission estimate applies (e.g., positive flowing junction boxes in SCAQMD).

V. COMPONENT IDENTIFICATION AND COUNTING METHODOLOGY:

The collected data used to develop the EPA 1995 emission factors were defined and counted using a specific methodology. In order to accurately calculate fugitive emissions from leaking equipment using the new correlation equations and emission factors, it is essential that users identify and count components in the same way. This section defines and illustrates how components are to be counted for use with the new emission factors. This section also provides examples of components which are not included in component counts when using the Correlation Equation Method (general or unit-specific) for the quantification of fugitive emissions.

Component Identification and Counting Guidelines:

Connectors: Connectors are threaded connectors and tubing fittings of all sizes (see section on component identification and screening illustrations). Connectors generally have an outside diameter of 3 inches or less but may be larger. Each connection interface, regardless of size, counts as one component. Each threaded connection of processing lines to a valve is considered a connector and should be counted as a connector. However, the body connection and bonnet of a valve, and drain plugs threaded directly into the valve body are considered part of the valve and should not be counted separately. A piece of pipe with one end connected to a valve and the second end open to the atmosphere is considered an "open-ended line," not a connector.

Flanges: A flange is a projecting rim on a pipe or piping component used to attach it to another flanged piping detail or component (see section on component identification and screening illustrations). Flanges are bolted connections generally having an outside diameter greater than 3 inches but may be smaller. Each bolted connection of processing lines to a valve is considered a flange and should be counted as one component. Heat exchanger heads and bundle joints of the tube and shell type heat exchanger are considered flanges and should be counted. However, bolted body connections of a valve are considered part of the valve and should not be counted separately. A piece of pipe with one end connected to a valve and the second end open to the atmosphere is considered an "open-ended line", not a flange. Body flanges on meters and filters, and hatches on tanks and vessels are not counted as flanges. They are included in the "Other" category.

Open-Ended Lines (Also called "open-ended valves"): An open-ended line is the end of any valve that can be opened to the atmosphere (i.e., sample connections, drains, bleed valves) (see section on component identification and screening illustrations). If a short piece of pipe is attached to the end of a valve, but no pressure build-up can occur in the pipe, the system is considered an open-ended line and not a connector or flange. The open end of a pressure relief valve is part of the valve and is not counted as an open-ended line. When two valves are installed in series and both are closed (creating a double seal to prevent loss to atmosphere) the open end of the second valve is not counted as an "open-ended line". This system is counted as 2 valves. An outlet line sealed with a plug or cap is not considered an open-ended line. The plug or cap is a connector or flange.

Pump Seals: Pump seals are located at the interface of the pump shaft and housing and other joints of the pump (see section on component identification and screening illustrations). A pump is defined as a device that raises, transfers or compresses fluids by suction or pressure or both. Pumps are used to transport fluids by the addition of energy. All associated components such as

connectors, flanges, and valves are counted in their respective categories. Pumps that are connected to vapor recovery systems or flare headers, are not counted.

Valves: Valve is a device that regulates or isolates the fluid flow in a pipe, tube, or conduit by means of an external actuator. Each valve is counted once regardless of the number of body flanges, bonnet flanges or plugs that are a part of the valve (see section on component identification and screening illustrations). Drain valves or vent valves attached to other valves are counted as separate valves. Only valves that have visible actuators are counted. Check valves and pressure relief valves (PRVs) are not counted as valves; they are included in the "Others" category. However, PRVs should be counted separately for refineries since there are average factors and screening value range factors for PRVs at refineries. Each connector or flange of a valve to a processing line is counted as a connector or flange and is not considered part of a valve.

Others: The "Other" component category includes: compressor seals, diaphragms, process drains, dump lever arms, access doors, hatches on tanks and vessels, instruments (i.e., pressure gauges, thermocouples if not sealed, sensing elements), meters, pressure relief valves (PRVs), polished rods stuffing boxes, sight glasses, truck loading arms, and degassing vents. Any component type which is not a connector, flange, open-ended line, pump seal, or valve is included in the "Other" category. However, compressor seals and PRVs should be counted separately for refineries since there are average factors and screening value range factors for compressor seals and PRVs at refineries. Additionally, if an acceptable emission estimate exists which more accurately predicts emissions from the source, that component type should also be counted separately. For example, in the SCAQMD, it has been found that junction box vents which exhibit positive flow cause a higher mass emission rate than that predicted by the 1995 EPA "other" category. The SCAQMD used the following correlation:

Emissions from Positive Flowing Junction Boxes	=	$1.428\text{E-}04(\text{SV})^{1.02} \text{ kg/hr}$
---	---	--

"Inaccessible" Components: Inaccessible components is any component located over fifteen (15) feet above ground when access is required from the ground; or any component located over six (6) feet away from a platform when access is required from the platform. All inaccessible components are counted in the respective component categories.

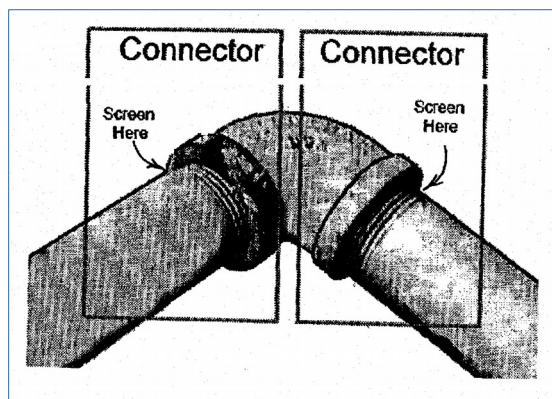
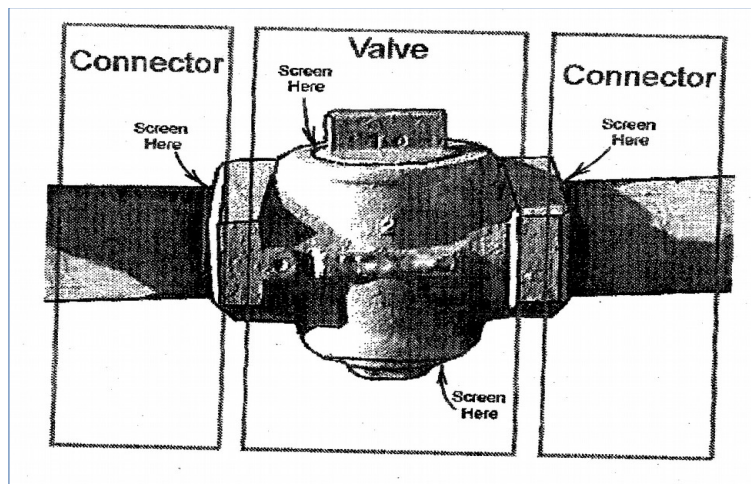
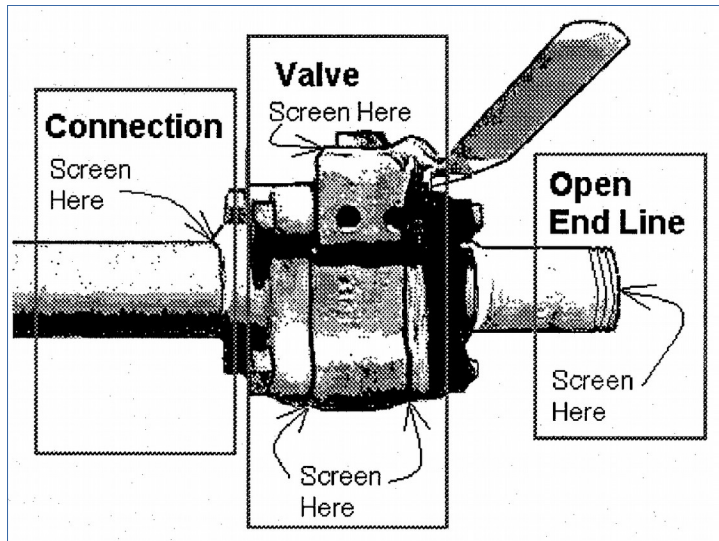
Unsafe to Monitor Components: Unsafe to monitor components are components installed at locations that would prevent the safe inspection or repair of components as defined by Occupational Safety and Health Act (OSHA) standards or in provisions for worker safety found in 29 Code of Federal Regulations (CFR) 1910. All unsafe to monitor components are counted in the respective component categories and assigned a default zero reading unless it is shown to the contrary by the districts.

Components Not Counted:

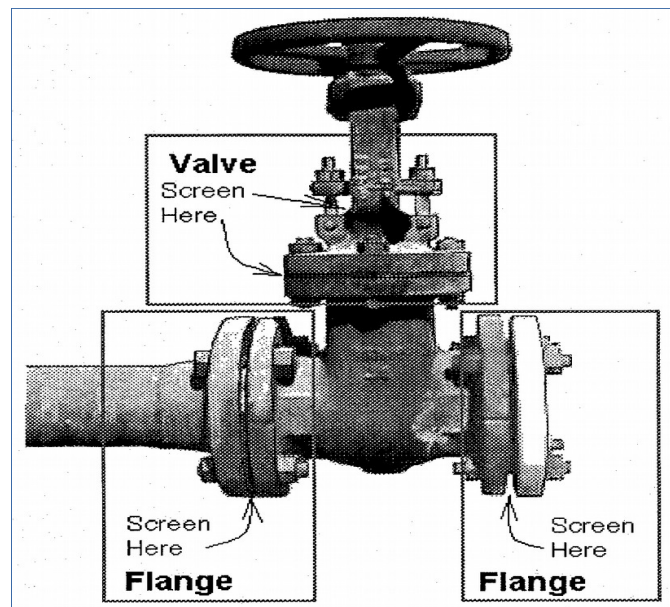
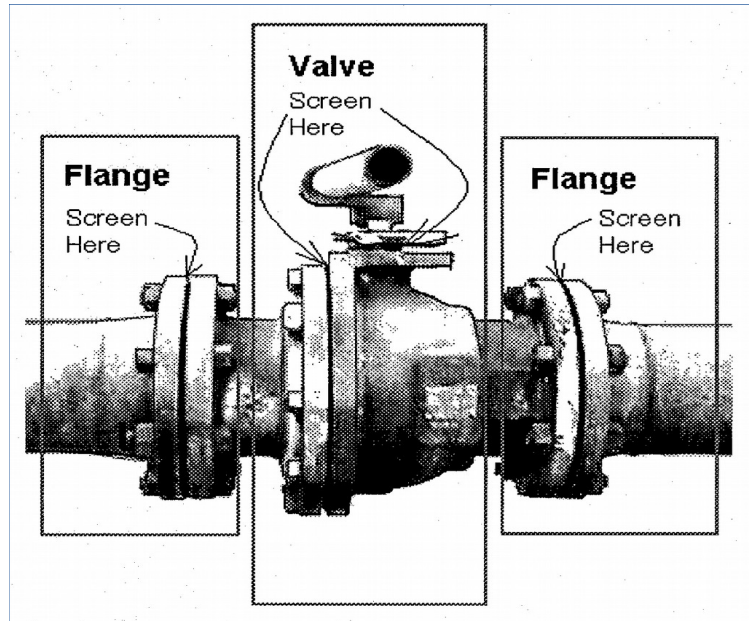
The following components are not included in component counts used for the quantification of fugitive emissions.

- ▶ components handling commercial natural gas
- ▶ components handling fluids of 10% by weight or less volatile organic compound
- ▶ components operating under negative pressure at all times
- ▶ components totally enclosed or contained such that there are no VOC emissions to the atmosphere.
- ▶ components handling non-volatile lubricating fluids
- ▶ components handling non-volatile hydrocarbon fluids used as heat transfer mediums, such as Therminol and glycol
- ▶ components buried below ground or under water
- ▶ components handling exclusively liquids which evaporate 10% or less at 150 °C
- ▶ components in water streams after primary separation at light crude oil production facilities
- ▶ components where a hydrogen sulfide (H_2S) exposure danger is present.
- ▶ components handling instrument air
- ▶ components on liquid drain lines downstream of the second block valve
- ▶ components on discharge lines of pressure relief devices that discharge to the atmosphere (however, the final discharge point will be considered as an open ended line)

Component Identification and Screening Illustrations:



COMPONENT ILLUSTRATIONS CONTINUED__



VI. COMPONENT SCREENING PROCEDURES:

The component screening methodology including specifications and calibration requirements of the hydrocarbon monitoring instrument is detailed in EPA Reference Method 21 published in 40 CFR 60, Appendix A (EPA Method 21). Additional discussions of monitoring instruments, their performance, application, and maintenance are presented in the 1995 EPA Protocol. The 1995 EPA Protocol also discusses the procedures for screening equipment.

This section documents the component screening procedures and the specifications of the monitoring instrument used by the contractors during the underlying studies. This section contains additional criteria that may be more stringent than EPA Method 21 when used for estimating mass emissions. Included are pictorial diagrams illustrating screening points for several component types (see component identification and screening illustrations in Section V). This section also discusses certification of operators in the use of fugitive emissions monitoring equipment.

Monitoring Instrument Specifications:

The sensitivity of the monitoring instrument to measure leaks is mainly a function of the instrument flow rate, response time, probe diameter, and the calibration standards which the instrument is calibrated with. The portable hydrocarbon monitoring instrument used during the 1993 fugitive emission studies is the organic vapor analyzer (OVA) which utilizes the principle of hydrogen flame ionization for detection and measurement of organic vapors. Since only OVAs were used to measure leaks in those studies, it is unclear how the results would be affected had other detection instruments allowed by Method 21 been used. Therefore, the following additional criteria are recommended:

Instrument flow rate:

It has been shown that instrument flow rate has a great affect on screening value. This is caused by the effects of capture efficiency and mixing with background air during sampling as well as the response of the detector. For this reason it is imperative that instrument flow rates be maintained similar to those used in the development studies. Therefore, a flow rate specification of 0.7 - 1.2 liter per minute is suggested.

Response time:

Response time is a critical variable since the entire screening act in most applications takes less time than the Method 21 maximum allowable response time of 30 seconds to 90% of the maximum reading. It is believed that a 5 second response time to maximum reading is achievable with the OVA instrument and must also be achieved by any instrument used for estimating mass emissions in order to maintain equivalency.

Probe diameter:

Probe diameter may be influential since it is a limiting factor to how close the probe may get

to the actual leak interface. The OVA instrument probe has an outside diameter of 3/16 inch.

Calibration standards:

The instruments in the development studies all used methane in air as the calibration standards. To maintain equivalency, the same calibration standards must also be used. This would also inherently eliminate the use of photoionization analyzers which generally show poor response to petroleum components.

In addition, compelling evidence indicates that screening data taken by OVAs fitted with dilutor kits are of undemonstrated reliability. Detailed discussion of this issue is presented in Attachment 3 of the SBCAPCD draft report, dated May 1, 1997, entitled *Review of the 1995 Protocol: The Correlation Equation Approach To Quantifying Fugitive Hydrocarbon Emissions At Petroleum Industry Facilities*. A copy of Attachment 3 is contained in Appendix E. The CARB is currently investigating this concern and an addendum to this document will be provided once the investigation is complete. In the interim the use of a dilution probe will be at the district's discretion.

Component Screening Guidelines:

It has been observed that during the development stage of the U.S. EPA correlation equations and emission factors, much care was taken during screening to identify the maximum screening value. During routine I&M inspections, however, screenings are performed more hastily. This is verified by the observation that discrepancies found in district's audits are located in harder to reach areas such as in higher locations. Additionally, maximum leaks often occur on the sides of the components facing away from access points or walkways. As a result, often times maximum leaks are not obtained or repaired during inspections. For this reason, the following guidelines are recommended.

The guidelines are based mainly on the screening methodology detailed in EPA Reference Method 21 published in 40 CFR 60, Appendix A (Method 21). However, in some cases, the guidelines may be more stringent than Method 21.

Basic screening instruction:

Place the probe inlet of the monitoring instrument at the surface of the component interface where leakage could occur such that the probe contacts the surface and minimizes the space between the interface and the probe. For equipment with moving parts, the probe should be placed no more than 1 centimeter from the surface. Move the probe along the interface periphery allowing a sufficient amount of time for the instrument to respond while observing the instrument readout. During this step the probe must not be moved at a rate of greater than one linear inch per instrument response time and the movement must encompass the entire interface. If there is an increase in the meter reading, sweep back past the location at a slower movement rate and monitor the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. Record the highest reading. This procedure must also be repeated on all interfaces of a multiple interface component.

Background screening instruction:

Determine the local ambient concentration around the source by moving the probe inlet randomly upwind and downwind at a distance of one to two meters (three to seven feet) from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters (about 10 inches).

Specific components screening instructions:

Flanges and Other Connectors - Monitor the entire circumference of the flange-gasket interface. Monitor the entire circumference of threaded connections, tubing fittings, and other types of non-permanent joints.

Open-Ended Lines or Valves - Place the probe inlet at the center of the opening to atmosphere.

Pump and Compressor Seals - Monitor pump seals at the point where the shaft exits the seal. If the source is a rotating shaft, position the probe inlet within 1 cm of the shaft-seal interface. If the housing configuration prevents a complete check of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage could occur.

Valves - Monitor all of the area where the stem comes out of the packing gland. Monitor any body flanges, bonnet flanges, or plugs on the valve.

Others - Monitor other components such as diaphragms, dump arms, instruments, meters, polished rods stuffing boxes, etc. at all points of possible emissions. Below are additional screening instructions for specific “others” components:

Access Door Seals and Hatches - Place the probe inlet at the surface of the door seal interface and monitor along the periphery.

Pressure Relief Devices Vented to Atmosphere - The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

Process Drains, Manhole Covers, Junction Box Vents and Sewer Vents - If open, place the probe inlet at approximately the center of the area open to the atmosphere. If covered, place the probe at the surface of the cover interface and monitor along the periphery.

Seal System Degassing Vents and Accumulator Vents - Place the probe inlet at approximately the center of the opening to the atmosphere.

Operator Training and Certification:

To ensure that all operators are trained in the use of fugitive hydrocarbon monitoring instruments, including when the use of diluter kits is acceptable, CAPCOA recommends that a training program be established. Such training will improve the quality of data that are collected and reported to the districts. Cost of the program will be kept to a minimum. Training and/or certification will not replace district audits. This concept will be further evaluated and developed as a separate entity aside from the guidelines.

VII. LEAK QUANTIFICATION METHODS:

Leaks are quantified by mixing the fugitive hydrocarbon in a known quantity of air (or nitrogen) and determining the resulting hydrocarbon-to-air (or nitrogen) ratio. Three methods have been used by the U.S. EPA to quantify leaks: the vacuum method, the blowthrough method, and the high volume collection system (HVCS). The three methods share some common features.

The Vacuum Method

The vacuum method of quantification begins by sealing a bag of thin plastic or other impermeable material around a leaking component. A vacuum pump is used to draw air through the bag at a measured rate of up to 60 liters per minute. A sample of the gas from the pump outlet is analyzed for hydrocarbon content, either as parts-per-million by volume (ppmv) or total hydrocarbon, or as ppmv of methane, ethane, propane, etc.

The mass of the fugitive leak is calculated by multiplying the ppmv results by the total volume of air-hydrocarbon mixture flowing through the pump during sampling.

Section 4.2.1 of the 1995 EPA Protocol describes one of many configurations that can be used for the vacuum method. Different types of plastic or foil can be used to construct the bag, and various hydrocarbon analysis techniques can be used for analyzing the collected sample.

The Blowthrough Method

The blowthrough method is similar to the vacuum method except that compressed gas (such as nitrogen) is blown into the bag at a measured rate of up to 60 liters per minute and no pump is used at the outlet. A sample of the mixture inside of the bag is collected for analysis.

Section 4.2.2 of the 1995 EPA Protocol, which describes the method in detail, states that in addition to the compressed gas, ambient air sometimes enters the bag. For this reason, calculation of the hydrocarbon leak rate requires a correction for both air inflow and hydrocarbon

volumetric flow. The equation for calculating the leak rate is the following:

Where:

- GC = Lab reported THC in units of ppmv
- MW_{cg} = Molecular weight of laboratory calibration gas
- 22.413 = Molar volume at 0 °C in m³/kg-mol
- T = Ambient temperature in Celsius
- MW_{hc} = Molecular weight of the leaking organic compound

The following default values for the term MW_{hc} have been accepted for use: for gas streams, MW_{hc} = 30 lb/lb-mol, for light liquid streams, MW_{hc} = 60 lb/lb-mol, for heavy liquid stream, MW_{hc} = 100 lb/lb-mol.

- ρ = Density of the organic liquid collected from dripping component (g/ml)
- V_L = Volume of liquid collected (ml)
- t = Time during which liquid was collected (in minutes)
- 16.67 = Conversion from g/min to kg/hr

The 1995 EPA Protocol suggests that the bag be constructed of plastic that is impermeable to the hydrocarbon being collected.

The High Volume Collection System (HVCS)

The High Volume collection System is similar to the vacuum method except that flow rates through the pump are as high as 500 liters per minute and the hydrocarbon-to-air ratio is measured directly at the pump outlet using the same monitoring instrument that was used for initial screening of the components. The fugitive leak rate is calculated by multiplying the volumetric flow through the pump by the ppmv of hydrocarbon. The method is described in detail in the U.S. EPA document, dated November 1995, entitled *Evaluation of the High Volume Collection System (HVCS) for Quantifying Fugitive Organic Vapor Leaks* (EPA-600/R-95-167).

VIII. DEFINITIONS:

API Gravity: The density of the liquid expressed in degrees and defined by the following equation:

$$\text{API Gravity} = (141.5 / \text{Sp. Gr.}) - 131.5,$$

where Sp. Gr. is the specific gravity of the liquid at 60°F.

Average Emission Factor: The average mass emission rate for the total population (including leakers and non-leakers) of a component type.

Bagging: Enclosing a leaking component in plastic film or a metal foil enclosure is referred to as bagging. Bagging is used to gather a sample of leaking hydrocarbon. Typically ambient air is drawn through the bag to catch the hydrocarbon (vacuum technique or High Volume Collection System) or nitrogen is blown into the bag to mix with the hydrocarbon (blowthrough technique). Either way, one or more samples of the hydrocarbon/carrier gas mixture is collected for laboratory analysis.

Blowthrough Bagging Method: A leak quantification technique that uses compressed gas (usually nitrogen) to sweep fugitive hydrocarbons through a plastic or metal foil bag fastened tightly around the leaking component. The hydrocarbon fraction in the nitrogen/hydrocarbon mixture is determined by gas chromatography or other laboratory techniques.

Calibration Gas: The U.S. EPA has specified that monitoring instruments are to be calibrated with mixtures of methane-in-air. A commonly used calibration gas for the high range of the monitoring instrument is 10,000 parts-per-million by volume, methane-in-air.

Connectors (See **Component**).

Component:

Connectors: Connectors are threaded connectors and tubing fittings of all sizes. Connectors generally have an outside diameter of 3 inches or less but may be larger. Each connection interface, regardless of size, counts as one component. Each threaded connection of processing lines to a valve is considered a connector and should be counted as a connector. However, the body connection and bonnet of a valve, and drain plugs threaded directly into the valve body are considered part of the valve and should not be counted separately. A piece of pipe with one end connected to a valve and the second end open to the atmosphere is considered an "open-ended line," not a connector.

Flanges: A flange is a projecting rim on a pipe or piping component used to attach it to another flanged piping detail or component. Flanges are bolted connections generally having an outside diameter greater than 3 inches but may be smaller. Each bolted connection of processing lines to a valve is considered a flange and should be counted as one component. However, bolted body connections of a valve are considered part of the valve and should not be counted separately. A piece of pipe with one end connected to a valve and the second end open to atmosphere is considered an "open-ended line"

not a flange. Body flanges on meters and filters, and hatches on tanks and vessels are not counted as flanges. They are included in the "Other" category.

Open-Ended Lines (Also called "open-ended valves"): An open-ended line is the end of any valve that can be opened to the atmosphere (i.e., sample connections, drains, bleed valves). If a short piece of pipe is attached to the end of a valve, but no pressure build-up can occur in the pipe, the system is considered an open-ended line and not a connector or flange. The open end of a pressure relief valve is not counted as an open-ended line. When two valves are installed in series and both are closed (creating a double seal to prevent loss to atmosphere) the open end of the second valve is not counted as an "open-ended line". This system is counted as 2 valves. An outlet line sealed with a plug or cap is not considered an open-ended line. The plug or cap is a connector or flange.

Pump Seals: Pump seals are located at the interface of the pump shaft and housing and other joints of the pump. A pump is defined as a device that raises, transfers or compresses fluids by suction or pressure or both. Pumps are used to transport fluids by the addition of energy. All associated component such as connectors, flanges, and valves are counted in their respective categories. Pumps that are connected to vapor recovery systems or flare headers are not counted.

Valves: Valve is a device that regulates or isolates the fluid flow in a pipe, tube, or conduit by means of an external actuator. Each valve is counted once regardless of the number of body flanges, bonnet flanges or plugs that are a part of the valve. Drain valves or vent valves attached to other valves are counted as separate valves. Only valves that have visible actuators are counted. Check valves and pressure relief valves (PRVs) are not counted as valves; they are included in the "Others" category. However, PRVs should be counted separately for refineries since there are average factors and screening value range factors for PRVs at refineries. Each connector or flange of a valve to a processing line is counted as a connector or flange and is not considered part of a valve.

Others: The "Other" component category includes: compressor seals, diaphragms, process drains, dump lever arms, access doors, hatches on tanks and vessels, instruments (i.e., pressure gauges, thermocouples if not sealed, sensing elements), meters, pressure relief valves, polished rods stuffing boxes, sight glasses, truck loading arms, and degassing vents. Any component type which is not a connector, flange, open-ended line, pump seal, or valve is included in the "Other" category. However, compressor seals and PRVs should be counted separately for refineries since there are average factors and screening value range factors for compressor seals and PRVs at refineries. Additionally, if an acceptable emission estimate exists which more accurately predicts emissions from the source, that component type should also be counted separately. For example, in the SCAQMD, it has been found that junction box vents which exhibit positive flow cause a higher mass emission rate than that predicted by the 1995 EPA "other" category. The SCAQMD used the following correlation:

Emissions from Positive Flowing Junction Boxes	=	1.428E-04(SV) ^{1.02} kg/hr
---	---	-------------------------------------

Inaccessible Components: “Inaccessible” components is any component located over fifteen (15) feet above ground when access is required from the ground; or any component located over six (6) feet away from a platform when access is required from the platform. All inaccessible components are counted in the respective component categories.

Unsafe to Monitor Components: Unsafe to monitor components are components installed at locations that would prevent the safe inspection or repair of components as defined by Occupational Safety and Health Act (OSHA) standards or in provisions for worker safety found in 29 Code of Federal Regulations (CFR) 1910. All unsafe to monitor components are counted in the respective component categories and assigned a default zero reading unless it is shown to the contrary by the districts.

Correlation Equation: An equation that relates fugitive hydrocarbon mass emission rates in kilograms/hour, pounds/day, or pounds/year to instrument screening values in parts per million by volume. Correlation equations are used to calculate emissions from individual instrument screening values.

Default Zero: An average emission rate to be used for components that do not give instrument screening values higher than the background reading.

Emission Factor: The average mass fugitive emission rate for components in a specific screening value range. The factor is multiplied by the number of components to calculate fugitive emissions.

Flanges (See **Component**)

Fugitive Hydrocarbon Emissions: The term "fugitive" refers to unintentional emissions of hydrocarbon gases or liquid from valve stems, connections, shaft seals, etc. Occasional or continuous release of emissions through stacks or vents, whether intentional, accidental, or the results of a shut-down, start-up or emergency procedure are not considered fugitive emissions.

Gas (See **Service**)

Heavy Liquid/Heavy Oil(See **Service**)

High Volume Collection System: A leak quantification technique that uses a high flow of air to capture fugitive hydrocarbon leaks. The hydrocarbon fraction in the air/hydrocarbon mixture is determined using a portable hydrocarbon monitor.

Inaccessible Components (See **Component**)

Leak Frequency: The number of leaks per 100 components.

Light Liquid/Light Oil (See **Service**)

Marketing Terminal: A facility which handles the transfer or storage, or both, of petroleum products or crude petroleum in pipelines.

Monitoring Instrument: Portable monitoring instruments with internal pumps and hydrocarbon detectors. They are used to locate and/or quantify fugitive hydrocarbon emissions from equipment components.

Oil and Gas Production: A facility at which crude petroleum and natural gas production and handling are conducted, as defined in the Standard Industrial Classification Manual as Industry No. 1311, Crude Petroleum and Natural Gas.

Open-Ended Lines (See **Component**)

Other Component (See **Component**)

Organic Vapor Analyzer (OVA): A portable hydrocarbon monitoring instrument used during the 1993 fugitive emission studies which utilizes the principle of hydrogen flame ionization for detection and measurement of organic vapors.

Parts-per-million by Volume (PPMV): Most hydrocarbon monitoring instruments have displays that show the response of the instrument to known concentrations of methane-in-air measured in parts of methane per million parts of air by volume.

Pegged Source: An equipment component with fugitive hydrocarbon emissions that cause the monitoring instrument to exceed its maximum useful range. Because of this, no precise instrument screening value can be obtained for the component and it is referred to as a "pegged source".

Pump Seals (See **Component**)

Refinery: A facility that processes petroleum, as defined in the Standard Industrial Classification Manual as Industry No. 911, Petroleum Refining.

Screening: Monitoring an equipment component for fugitive hydrocarbon emissions usually through the use of a portable instrument.

Screening Instrument (See **Monitoring Instrument**)

Screening Value Range Emission Factor: The average mass emission rates for components with instrument screening values above an arbitrary leak definition (such as 10,000 ppmv) and below that definition.

Service:

Gas: Material in a gaseous state at operating conditions. Liquefied gases are considered light oil.

Light Liquid/Light Oil: Oil produced at production sites having an API Gravity of 20 or more. Bearing seal oils and hydrocarbon-based heat transfer fluids are also included in this category. Light hydrocarbons (such as propane and butane) that are in a liquid state inside of the components due to high pressure and/or low temperature are also included in this category. This category includes both pure liquid streams and streams that are mixtures of light liquids and gases.

Heavy Liquid/Heavy Oil: Oil produced at production sites having an API Gravity of less than 20. Pure liquid streams and streams containing mixtures of heavy oil and gases are included in this category.

Water/Light Oil: Water streams in light oil service with a water content greater than 50%, from the point of origin to the point where the water content reaches 99%. Components carrying water streams with a water content greater than 99% are not counted. Emission factors for water/light oil service should be used for components on oil-water separators, components on produced water tanks and components on piping and other equipment used for handling produced water prior to its injection underground.

THC and ROC: Total hydrocarbons (THC) include methane, ethane, propane, and any other organic molecule containing carbon. Reactive Organic Compounds (ROC) are defined differently by agencies but typically methane and sometimes ethane are not counted as ROCs.

Unsafe to Monitor Components(See **Component**)

Vacuum Bagging Method: A leak quantification technique that uses a vacuum pump to pull ambient air through a plastic bag fastened tightly around a leaking component. The hydrocarbon fraction in the resulting air/hydrocarbon mixture is determined by gas chromatography or other laboratory technique.

Valves (See **Component**)

Water/Light Oil (See **Service**)

REFERENCES

1. U.S. EPA, *Protocol for Equipment Leak Emission Estimates*, EPA-453/R-93-026, June 1993.
2. U.S. EPA, *Protocol for Equipment Leak Emission Estimates*, EPA-453/R-95-017, November 1995.
3. *1993 Study of Refinery Fugitive Emissions from Equipment Leaks, Volumes I, II, and III*, Radian DCN No. 93-209-081-02, Radian corporation, prepared for Western States Petroleum Association, Glendale, CA, and American Petroleum Institute, Washington, D.C., 1994.
4. *Development of Fugitive Emission Factors and Emission Profiles for Petroleum Marketing Terminals, Volumes I and II*, API 4588, Radian Corporation, prepared for American Petroleum Institute, 1993.
5. *Fugitive Hydrocarbon Emissions from Oil and Gas Production Operations*, API 4589, Star Environmental, Prepared for American Petroleum Institute, Washington, D.C., 1993.
6. *Emission Factors for Oil and Gas Production Operations*, API 4615, Star Environmental, Prepared for American Petroleum Institute, Washington, D.C., 1995.
7. Letter dated April 26, 1994 from Robert Strieter of American Petroleum Institute to David Markwordt of U.S. EPA, Re: The submittal of gasoline distribution facility fugitive equipment screening data.
8. *Calculation Workbook for Oil and Gas production Equipment Fugitive Emissions*, API 4638, STAR Environmental, Prepared for American Petroleum Institute, July 1997.
9. Memorandum dated February 27, 1997 from David Epperson of Eastern Research Group to David Markwordt of U.S. EPA, Re: Draft Analysis of Alternative Mass Emission Calculation Methods for the Blow-Through Bagging Method.
10. Santa Barbara County APCD, *Review Of The 1995 Protocol: The Correlation Equations Approach To Quantifying Fugitive Hydrocarbon Emissions At Petroleum Industry Facilities*, Draft Report, Santa Barbara, May 1, 1997.
11. Letter dated June 18, 1997 from Ronald D. Ricks of Radian to Frank E. Holmes of Western States Petroleum Association.

12. Fax Transmittal dated July 23, 1997 from Ray McCaffrey of Santa Barbara County APCD to Members of Correlation Equations Review Group, Re: SBCAPCD Comments on Radian's 6/18/97 Response to our 5/1/97 Draft Report.